Schafer

Support to the Smart Munitions Test Suite White Sands Missile Range

February 1999

Prepared by:

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703/558-7900

Task Report – Naval Research Laboratory
Contract N00014-97-D-2014/001

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Support to the Smart Munitions Test Suite
White Sands Missile Range

Schafer Corporation is providing support to the White Sands Missile Range (WSMR) National Range Development Directorate. This activity is directly in support of the Smart Munitions Test Suite (SMTS) which is a unique asset developed by WSMR to enhance the Test and Evaluation Community's ability to evaluate weapons systems by combining test with modeling and simulation. Reduced test budgets have lead to fewer field tests resulting in both a greater reliance in simulation to fill in the test matrix and enhancing the value of those tests performed. With fewer tests being performed each test must have its success maximized and this too enhances the value of simulation especially for mission rehearsal. SMTS performs all of the necessary functions to maximize the weapons system evaluation process.

Developed at WSMR the SMTS is designed to meet the specific challenges of today's test environment. Using a modular command and control architecture, the SMTS, which is completely mobile, can be rapidly configured to support a broad range of missions.

Specialized SMTS capabilities include a powerful, transportable modeling and simulation capability that emphasizes pre-mission planning and rehearsal. The heart of SMTS is real-time acquisition and tracking capability based on an optimal real-time fusion of radar, optics, Global Positioning System (GPS), and other sensors all of which can handle up to 80 objects simultaneously. Finally, the SMTS provides a self-contained ability to reduce trajectory data, including automated film data reduction, on the test site itself. All of these features, along with the ability to support expert system man-in-the-loop fly-bys (with heads-up display), ensure a very diverse set of applications.

The SMTS consists of the following subsystems:

Master Control Van
Data Acquisition and Analysis Van
Enhanced Multiple Object Tracking Radar
Smart Munitions Tracking Mounts
Smart Munitions Distant Object Attitude Measuring System

In addition, interfaces to the following sources of time-space-position-information (TSPI) are active:

GPS
Precision Acquisition System (standard range radar included)
Ancillary inputs (10 each)

As a result of the modular architecture, the SMTS acquisition and tracking sensor front end can be configured for particular test scenarios covering a very broad range of missions that no single sensor type could cover.

Under previous contractual activity, Schafer performed assessments for SMTS on its suitability to several Department of Defense (DOD) and non-DOD applications. We reviewed SMTS performance as part of different DOD field exercises and made inputs on the systems performance during those exercises. Schafer also assessed SMTS performance in support of WSMR Theater Missile Defense testing and identified improvements which could be brought to the overall range coverage of these tests. In particular, we identified to WSMR the advantages of obtaining the ARPA Airborne Infrared Measurement System (AIRMS) mount and telescope to aid in monitoring the end game for TMD

missions. WSMR has in fact obtained that mount and Schafer developed concepts for using that mount. During this contract year, Schafer helped WSMR develop a white paper on the use of mount and the utility of the "nested sensor" approach. The input to the white paper is provided as appendix A.

Part of Schafer's activity was to help WSMR identify utility to support the development, simulation and testing of the DOD ACTD programs. Working with WSMR, we developed a briefing used by WSMR to brief their capabilities. This is provided in appendix B. Discussions of these capabilities were held with personnel from Extended Littoral Battlefield and Military Operations on Urban Terrain ACTDs. However, the ACTD where SMTS has provided real capability is in support of THEL.

SMTS radars and mounts have provided independent tracking of the Katyusha rockets which are the targets that THEL is designed to negate. To date, SMTS provides the independent tracking for the THEL radar acquisition tests and provides the Best Estimate of Track (BET) in a timely (hours after test) manner to verify THEL radar acquisition and help plan subsequent tests. In the future, SMTS mounts will be provided to help verify optical tracking and laser aimpoint maintenance by mounting TRW provided sensors which are the return power sensors used for simulated fire track experiments and using SMTS sensors to provide scoring for the laser flight tests. These would be used to look in band to the laser to verify the aimpoint of the HEL on the rocket, measuring both the drift as well as the size of the beam as a function of system radiation time. In addition a second sensor (out of band) will look at the thermal strip caused by the laser. The SMTS mounts are ideal for this application as they can be retargeted in synch with the THEL Pointer Tracker.

The capabilities of SMTS are so well matched to the THEL that TRW requested that Schafer and WSMR consider proposing its use to provide a near term second line of sight for THEL by using SMTS as an adjunct tracker. An architecture to use SMTS in this role was developed and a proposal provided (not under this contract). Subsequent to this activity, an operational mount was identified which could serve this purpose.

Another program which SMTS and WSMR could support is the Discriminating Interceptor Technology Program (DITP). DITP is a BMDO interceptor program in which advanced sensors are being developed and integrated in a demonstration to show capability and maturity to address advanced NMD and TMD threats. The fact that SMTS supports all TMD tests conducted at WSMR and collects high fidelity data would permit it to support low cost, low risk validation of DITP hardware and software using both collected data and SMTS's Virtual Test Range capabilities. This would allow mission rehearsal and test the IFTU as well as potential tests of tracking and discrimination algorithms. It would also verify the transportability of the algorithms which would be of interest for future use of DITP in missile development programs. SMTS could also provide the mounts to perform integrated subsystem tests for both the breadboard and flight sensors. Using the data collected, it could support mission rehearsal for the eventual flight system tests and provide data collection if the tests are run at WSMR as presently planned. Since SMTS is mobile it could, in principal, support tests run at other test ranges using acceptable targets of opportunity thus collecting the data to support flight demonstration mission simulations. Discussions between WSMR and DITP personnel have been initiated and continue at this time.

Appendix A

Need for Additional Specialized WSMR Optical Sensor for TMD Intercept Characterization

Hit-to-kill TMD missile interceptor testing at the White Sands Missile Range (WSMR) would significantly benefit from the addition of an optical sensor which would serve to closely observe interceptors during their final fly-in to targets. This would provide critical data regarding performance of guidance systems and divert motors. There is a need for such data even during successful missions for full characterization of interceptor performance. In the event of mission failure such data can be critical in reaching a quick initial and subsequent comprehensive understanding of the causes leading to unacceptable performance.

Such an optical sensor would also serve as an additional source of high quality data enabling refinement of precision track for hit point or miss distance determination.

The analysis of system lethality and kill assessment algorithm performance would greatly benefit from high frame rate imaging of the intercept event. The data so obtained would include debris cloud growth rate, the shape of the debris cloud, its object size distribution, as well as its radiometric history.

TMD test flights at WSMR over the past two years have unequivocally indicated that such an optical sensor would be far more than generically beneficial in a marginal way. Instead such a sensor could be a prime source of mission critical data These recent test flights have clarified the four requirements that any candidate sensor system must meet to warrant consideration.

The first and most obvious of these requirements is that given budget realities any proposed solution be low cost and low risk while at the same time allowing a high quality mobile optical sensor to be positioned to optimize end game viewing and simultaneously minimizing atmospheric propagation losses in TMD testing.

The second requirement is that for maximum utility the optical sensor be capable of being positioned with east-west viewing to complement existing north-south looking assets to ensure complete geometrical coverage during TMD testing at WSMR.

The third requirement is that the candidate optical sensor system have a field of view, resolution, wavelength, frame rate and integration time commensurate with TMD testing needs. Given feasible pixel array sizes there will be of necessity a trade between the needed cross-range resolution at ranges of interest and the overall field of view. To derive maximum benefit from the available field-of-view both the interceptor which will be continuously observed and the oncoming target state vectors must be continuously monitored so as to position the sensor field of view optimally.

This drives the fourth requirement, that the optical sensor be closely tied into the proven existing WSMR Smart Munitions Test Suite (SMTS) real time acquisition and tracking capability to extract maximum value from the data collected.

CURRENT WSMR OPTICAL ASSET SITUATION

Planned TMD flight tests at WSMR will be flown on north-south headings. These flights include ongoing THAAD Dem/Val tests as well as Standard Missile 2, Block IV A flights. Present optical instruments have north-south viewing geometries and low altitude deployment. These include the Sea Lite Beam Director (SLBD) on the southeast corner, the Experimental Test Site (ETS) on northwest corner, and DOAMS telescopes on the central valley floor.

Previous attempts to provide end game east-west viewing have been less than successful. Using the lessons learned from those attempts the currently proposed approach satisfies the WSMR TMD testing need for end game instrumentation and at the same time permits easy deployment for TMD flights at other ranges.

PROPOSED "NESTED SENSOR" APPROACH

The rapid development of a mobile high resolution narrow FOV IR diagnostics system to be used in conjunction with existing wide FOV IR assets at WSMR will provide for "nested sensor" coverage of the end game for TMD testing.

The nested sensor approach captures impact and post impact phenomenology data with different degrees of resolution and fields of view. Interceptor trajectory analysis would greatly benefit from this dual resolution data in addressing operational performance issues such as those associated with the flight control systems and IMU aboard the interceptor. Both of these areas have proven problematic on THAAD flight tests. Even when nominal intercept success is achieved, careful monitoring of interceptor attitude and divert actions during fly-in can provide highly valuable data.

The likelihood of diagnostic mission success is greatly enhanced by capability for rehearsal of mount and sensor control to discover and correct any possible procedural problems in advance. The proposed sensor system would be an integral part of a proven system which permits such pre-mission rehearsals through real time hardware in the loop simulation.

Such simulations are carried out using the advanced data processing resources compactly contained within the WSMR Smart Munitions Test Suite (SMTS) MCV/DAAV Master Controller Van/Data Acquisition and Analysis Van. The WSMR Instrumentation Directorate pioneered state of the art multiple sensor coordination and data fusion with the SMTS.

Radar, visible, and IR sensor data and mount inputs are fused in real time to provide a high quality composite Best Estimate of Track (BET). This composite BET can keep nested narrow and wide FOV IR sensors on separate mounts locked on an interceptor during fly-in to target.

IR FOV, IFOV & FRAME RATE TUNED TO INTERCEPT REQUIREMENTS

By mating a David Sarnoff Research Center 800 x 600 pixel high frame rate IR camera system to an ARPA Airborne Infrared Measurement System (AIRMS) mount and telescope a sensor system is created which has the best trade applicable to the intercept diagnostic mission. This includes adequate FOV for observing the interceptor and target simultaneously during the final stages of fly-in and during the early post collision debris cloud creation and growth. At the same time the individual pixel IFOV of 12.5 μr yields approximately 1 meter cross range resolution at sensor to intercept distances of interest. This permits high resolution kalman filter tracking of the interceptor and target as well as accurate tracking of large debris pieces. The pixel IFOV thus represents an optimal trade off between the wide FOV desirable to image post collision phenomenology on intercept and the narrow pixel size necessary for imaging the interceptor and target during fly-in.

Over the FOV of interest frame rates from 30 to 120 frames per second are possible. Once the interceptor and target are both in the sensor FOV the higher frame rate can be selected permitting approximately 30 frames to capture the initial growth of the debris cloud to be studied in detail as it grows to 0.5 km in diameter. The frame rates and integration times are consistent with typical target and debris velocities.

Appendix B

Schafer

High Performance Computing for Enhancing ACTDs

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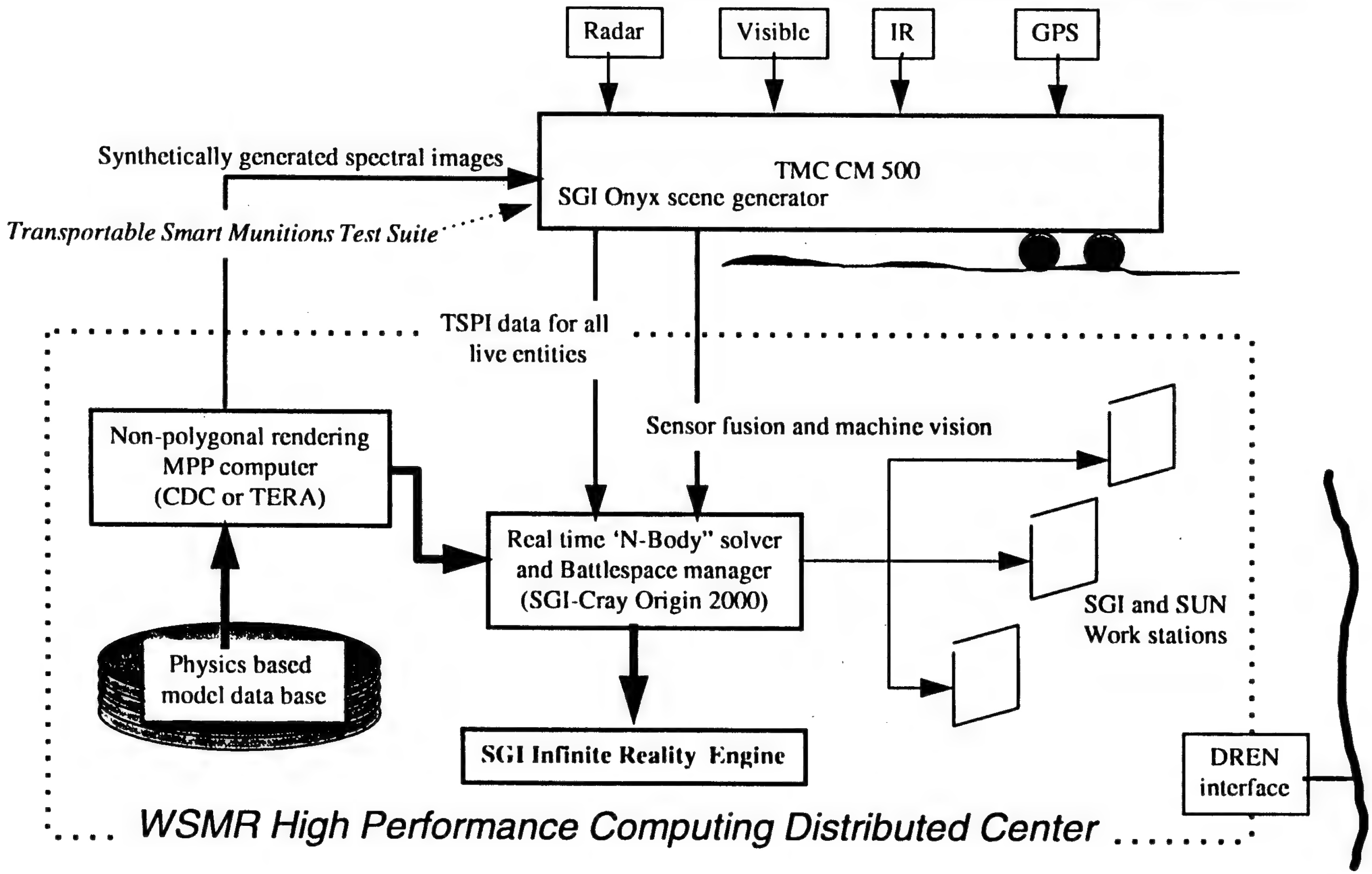
WSMR HPC DC


Radar
Visible
IR
GPS
TMC CM 500
SGI Onyx scene generator
Synthetically generated spectral images
Transportable Smart Munitions Test Suite
TSPI data for all live entities
Sensor fusion and machine vision
Non-polygonal rendering MPP computer (CDC or TERA)
Real time 'N-Body" solver and Battlespace manager (SGI-Cray Origin 2000)
Physics based model data base
SGI Infinite Reality Engine
SGI and SUN Work stations
DREN interface
WSMR High Performance Computing Distributed Center

Schafer **WSMR HPC DC**

- Benefits - enhance and accelerate ACTD process
  - Low latency real-time M&S of emerging weapons system concepts
  - Battle-harden new CONOPS and systems
  - Combine training and T&E
    - Virtual prototypes
  - Combine Hardware-in-loop with Human-in-loop
  - Adjudicate exercise
  - Quickly analyze failure mode effects in DT/OT
  - Support up to 10,000 live and virtual DIS/HLA entities
  - Immerse exercise in high fidelity environment
    - R-R, R-V, V-V

- Potential ACTD applications
  - Sell ACTD to user
    - Low cost <u>early</u> involvement in new CONOPS development - why wait 'til end of ACTD?
    - Immerse ACTD in complex, joint, contextual environment
  - Support ACTD planning
    - Early identification and resolution of problems
    - Interfaces with legacy or other emerging systems
  - Enhance probability of user sell-off
    - Train and T&E early in program
  - Start effective and focused transition activities earlier in program
    - Identify P3I
    - Identify and plan deferred activities

- Potential ACTD applications
  - **<u>Military Operations in Urban Terrain (MOUT)</u>**
    - M&S of entire scenarios
      - Hi-fi comms and sensors in hi-fi urban, littoral, jungle and mountainous terrain
      - Evaluation of competing technologies
      - Interaction with existing doctrine and systems
        - Rapid evaluation of doctrinal changes
      - Maneuver elements in hi-fi terrain
      - Hi-fi rendering of natural and man-made environments
        - Electromagnetic
        - Acoustic
        - Physical
      - Early assessment of MOE's

- Potential ACTD applications
  - **<u>Extending the Littoral Battlespace (ELB)</u>**
    - M&S of entire scenarios
      - BMC^3, comms and sensors in hi-fi urban, littoral, jungle and mountainous terrain
      - Targeting and weapons systems coordination
      - Interaction with existing doctrine and systems
      - Maneuver elements in hi-fi terrain
      - Natural and man-made environmental effects
      - Rapid evaluation of doctrinal changes
      - Early assessment of MOE's

- Potential ACTD applications
  - **Rapid Terrain Visualization**
    - M&S of entire scenarios
      - Hi-fi M&S of sensor alternatives
      - Hi-fi terrain and feature modeling
      - Near real-time data base construction
      - Real-time fusion of real and/or virtual multiple sources of sensory data - machine vision for:
        - Classification
        - Sorting
        - Decision making

- Potential ACTD applications
  - **Adaptive Course of Action (ACOA)**
    - Create realistic scenarios
      - Rich contextual environment for Red, Blue, Gray forces
        - Real entities
        - Virtual entities
      - Verify & demo utility of new doctrine & technology to CINC
      - Complex scenarios for stress testing
      - Interaction with existing doctrine and systems
        - DREN
        - GCCS/LES
      - Rapid evaluation of doctrinal changes
      - Improve and "harden" tools before ACTD
      - Early assessment of MOE's
      - Optimization of execution means and alternatives

- Potential ACTD applications
  - **Line-of-Sight Anti-Tank System (LOSAT)**
    - Create real-time high fidelity virtual simulation
      - LOSAT
        - Solve physics models in real-time -- sensors, platforms, weapon
        - Virtual, IPORT or human-in-the-loop
      - Targets
        - MODSAF or instrumented live entities
        - Solve physics models in real-time
      - Environment
        - Hi-fi terrain, features
        - Real and virtual entities
      - Complex scenarios for stress testing
        - Immerse LOSAT in realistic battlespace
        - Harden CONOPS